MSC-PA-R-68-14
Revision A

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 7 MISSION

15-DAY REPORT

(This report supersedes the Apollo 7 3-Day Report)

(NASA-TM-X-69429) APOLLO 7 MISSION 15-DAY REPORT (NASA) 27 p

N74-70893

Unclas
00/99 16375

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MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
NOVEMBER 1968

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November 5, 1968

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

This report is an update of the 3-Day Report; changes from that report are typed in *italics*.

The evaluation is based on preliminary data, and the values are subject to change. All times are referenced to range zero, the integral second before lift-off. Range zero was 15:02:45 G.m.t., October 11, 1968.

SUMMARY

The Apollo 7 space vehicle was launched from Cape Kennedy, Florida, at 11:02:45 a.m. e.d.t. on October 11, 1968. Following a nominal boost phase, the spacecraft and S-IVB combination was inserted into an orbit of 123 by 153 nautical miles. Prior to separation of the command and service modules from the S-IVB, the crew manually controlled the spacecraft/S-IVB combination. After separation, a transposition and simulated docking exercise was completed. Phasing maneuvers were later executed in preparation for a successful rendezvous with the S-IVB. During the 10.8-day flight, eight planned maneuvers using the service propulsion system were completed, and all major test objectives were satisfied.

Almost without exception, spacecraft systems operated as intended. All temperatures varied within acceptable limits and essentially exhibited predicted behavior. Consumable usage was always maintained at safe levels and permitted introduction of additional flight activities toward the end of the mission. Communications quality was generally good, and live television was transmitted to ground stations on seven occasions. A test of the rendezvous radar system was completed in support of later flights with the lunar module. Manual operation of the spacecraft by the crew was good. Even though they were somewhat hampered by head colds and congestion, the crew satisfactorily performed all flight-plan functions, and the photographic experiments were completed.

A normal deorbit, entry, and landing sequence was completed, with all parachutes operating properly. The vehicle landed at approximately *260:09:08* in the Atlantic Ocean southeast of Bermuda, with coordinates of 27° 33' north latitude and 64° 04' west longitude. The crew was retrieved by helicopter, and both the spacecraft and crew were taken aboard the prime recovery ship, *USS Essex*.

TRAJECTORY

The Apollo 7 launch trajectory was essentially nominal, with orbital insertion at 00:10:27. The orbital insertion conditions were a velocity of 25 551 ft/sec, a flightpath angle of 0.00 degree, and an altitude of 123.0 n. mi.

After the command and service modules were separated from the S-IVB, two phasing maneuvers for rendezvous were performed with the reaction control system. The rendezvous sequence was initiated over Carnarvon in revolution 17 at 26:24:56, with the first service propulsion maneuver. The second service propulsion maneuver was performed one revolution later to establish the necessary closing rate. The terminal phase was initiated during the 19th revolution at 29:16:45 using an onboard intercept solution. The crew reported station-keeping with the S-IVB at 30:00:00. A final separation maneuver from the S-IVB was performed in revolution 20 at 30:20:00.

This mission was the first in which transponder tracking was accomplished using the unified S-band system only. The overall quality of the unified S-band low-speed tracking data was good. Satisfactory trajectory fits have been obtained for all segments of the mission.

The deorbit maneuver occurred during revolution 163 over Hawaii at 259:39:16. The guidance and navigation controlled entry was nominal with landing at approximately 260:09:08.

Table I contains a summary of all rendezvous and subsequent service propulsion maneuvers. Table II contains the orbital elements for each maneuver.

SYSTEMS PERFORMANCE

STRUCTURES

Structural loads were below design limit values for all phases of flight. The peak ground winds just prior to lift-off were within *1 knot* of the structural red line; however, the measured launch vehicle strain data indicated that only 50 percent of the limit loads were encountered. The peak wind in the max q region was 52 ft/sec, and structural loads were less than 25 percent of limit. The axial load factor at the end of S-IB boost was 4.3g, compared with the design axial load factor of 4.86g.

Although the crew reported a "slightly bumpy" S-IVB flight, peak oscillatory accelerations measured in the command module did not exceed 0.05g in any direction, and structural loads were insignificant.

The deployment angle on one of the four adapter panels was less than 30 degrees. The acceptable angle is 34 to 50 degrees. Photographs show that the retention cable which should have held the panel fully open was missing.

THERMAL CONTROL

Temperatures of all passive elements of the spacecraft remained within limits for an earth orbit mission. The command module ablator temperature ranged from 3° to 95° F as expected. However, the service propulsion feedlines were warmer than expected; consequently, the heaters were not required. The monitored temperatures for the service propulsion and reaction control propellant and helium tanks slowly decreased throughout the mission. The "fracture mechanics" temperature limits were never approached during the flight. The thermal efficiency of the service module insulation appeared to be adequate based on the temperature histories of the tanks.

No specific instances of extended temperature increases were noted during the entire mission. Over the 3-hour period of the service propulsion system cold soak, all quad tanks showed a definite cooling trend. This type of response is indicative of what will occur on a translunar mission when the vehicle is not in the passive thermal control mode and the service module is being cold soaked.

THERMAL PROTECTION

The thermal protection system performed as expected. Sufficient data were obtained to allow evaluation of the flat apex thermal protection, and extrapolation to the design for manned lunar entry indicates no constraint for future missions.

Temperature measurements indicate the surface of the aft heat shield reached approximately 2700° F. Because the flight qualification recorder tape ran out 373 seconds before landing, the maximum in-depth temperature response cannot be determined.

The heat shield performed well during the mission. The aft heat shield was charred to a depth of approximately 0.5 inch. A maximum ablator temperature of 2500° F at 0.05 inch below the surface is indicated. The windward crew compartment heat shield (+Z) was slightly charred. The thermal coating remained attached to the leeside of the crew compartment heat shield, with no signs of hot spots. The white paint on the outside of the forward hatch was not affected by the entry heating, however, two nylon handles on the forward hatch were fused and partially disintegrated.

EARTH LANDING SYSTEM

The earth landing system performed satisfactorily. *Based on flight crew observations, the earth landing system functioned in the automatic sequencing mode, with all events occurring as planned.*

Preliminary postflight examination of the crew couch impact attenuation struts indicated that no stroking occurred.

MECHANICAL SYSTEMS

The mechanical system hardware functioned properly. The VHF recovery antenna and flashing light deployment mechanisms were erect and locked, and the flashing light performed satisfactorily when briefly turned on by the crew for checkout. The sea dye marker was not deployed.

The command module turned over to the stable II flotation attitude after a soft water landing and was subsequently returned to the upright (stable I) attitude by the uprighting system.

The unified side hatch apparently performed satisfactorily. The hatch counterbalance was recharged by the commander before hatch opening. The maximum torque required to open the hatch after recovery was a nominal

100 inch-pounds. Although the forward ablator and pressure hatches to the tunnel remained in the latched position during flight and landing, approximately 400 pounds of water flowed into the docking tunnel while the command module was in stable II. Further investigation will be required to determine how the water entered the tunnel.

AERODYNAMICS

The preliminary calculation for the entry lift-to-drag ratio at initial trim is 0.30, compared with the predicted value of 0.307. Later trim lift-to-drag ratios were as expected. The initial trim angle of attack was estimated as 160 degrees.

ELECTRICAL POWER AND SEQUENTIAL

Power Distribution

The electrical power system maintained the ac and dc voltages within nominal limits except for the discrepancies discussed in the following paragraphs.

The crew reported two ac bus 1 failure indications and one ac bus 1 and 2 failure indication early in the mission. Power was restored to normal by resetting the ac bus sensors. The occurrences were coincident with the cryogenic oxygen tank fans and heaters cycling OFF in the automatic mode. The only condition under which an ac bus can be automatically disconnected is an overvoltage being sensed by the ac overload sensing unit. After a procedural change was made to prevent the fans in both tanks from cycling OFF simultaneously, the problem did not recur for the remaining 200 hours of flight. *Postflight tests indicate that the cause is associated with arcing of a motor-operated switch which automatically controls the fans and heaters in the oxygen cryogenic tanks. The motor switch is environmentally sealed rather than hermetically sealed, thereby exposing the switch cavity to a high probability of bleeding down to pressures which support erratic arcing of the ac contacts. Both individual dropouts of ac bus 1 and ac bus 2 and simultaneous dropout of both have been reproduced during postflight tests with the cavity exposed to low pressures.*

Two other occurrences were associated with activation of the cryogenic tank fans: a master alarm was observed at the beginning of the cryogenic heater cycle at the time both buses dropped out, and the digital event timer started inadvertently once when the oxygen fans were turned on manually.

A discrepant undervoltage condition was encountered with the main A and B dc buses at command module/service module separation; this is discussed under batteries.

Fuel Cells

All power requirements imposed on the three fuel cells were satisfied.

Prior to the fifth service propulsion maneuver, the condenser exit temperature of fuel cell 2 increased from 160° to 180° F (nominal is 155° to 165° F). The electrical load was removed from fuel cell 2 for approximately 54 minutes to permit cooling prior to the service propulsion maneuver. Performance of the fuel cell was satisfactory during the maneuver. Four days later, the electrical load was again removed from fuel cell 2 for a short period of time as a precautionary measure to insure proper performance during the deorbit maneuver.

The data indicate a possible malfunction in the generator bypass valve which controls glycol flow to the condenser exit. Another possibility is that the flow in the glycol coolant loop was restricted. The result was that the glycol coolant entering the fuel cell from the spacecraft radiator was hotter than normal, and the condenser exit temperature subsequently increased under the higher power load. The load-sharing capability of the fuel cell was only slightly affected. Thermal control by the corresponding bypass valve in fuel cell 1 was abnormal in one instance; the condenser exit temperature increased to 175° F during the first period when only two fuel cells were carrying the load. It operated normally after fuel cell 2 was returned to the bus, and the problem was not evident the second time fuel cell 2 was removed from the bus.

Batteries

The voltage and current delivered by the entry batteries and pyrotechnic batteries were within the range of normal battery performance throughout the mission considering loads, states of charge, and ambient temperature in the areas in which the batteries were installed.

The charge rates on batteries A and B were much lower than expected. However, special ground tests performed during the flight showed that two factors contributed to this condition: line impedance between the battery and charger, and the particular characteristics of the battery and battery charger system under the flight conditions.

Results from charges conducted on the entry batteries reaffirm the inability to fully recharge in a reasonable time because of the line drop between the charger and the batteries.

The main bus voltage, as read out onboard at command module/service module separation, unexpectedly dropped to approximately 25.0 volts *and a low voltage alarm occurred,* but then gradually increased to a nominal level prior to blackout. *The low voltage did not affect operation of any system. Two factors producing this condition are low temperatures and states of charge on the batteries.*

Sequential

During the mission, the sequential system performed emergency detection system abort enable, tower jettison, launch-vehicle/spacecraft separation, command module/service module separation, and the earth landing functions (see table III for a list of mission event times).

The logic and pyrotechnic bus supplied the sequential system with the proper voltages throughout the flight.

CRYOGENICS

The cryogenic storage system performed satisfactorily during the mission. Excess reactants were available because spacecraft power levels were slightly below those predicted for the mission and because at lift-off there were 0.74 pounds of hydrogen and 42.7 pounds of oxygen above the respective minimum fill levels.

Automatic quantity balancing in the oxygen tanks was accomplished within 1-1/2 percent even though the fans in oxygen tank 2 were not operated automatically for a major portion of the mission. Automatic quantity balancing in the hydrogen tanks and one manual quantity adjustment were successfully performed. The criteria for this mission were balancing to within 3 percent.

Heat leak values of approximately 80 Btu/hr on the oxygen tanks after the launch phase vibration were as expected since the VAC-ION pumps were not energized. As the mission continued, the heat leak values decreased to 25 Btu/hr and the predicted oxygen venting did not occur. The favorable phenomenon of heat leak decrease cannot be explained at this time.

As previously mentioned, an overvoltage condition occurred three times in the ac electrical system. Coincidently in each case, the four oxygen tank fans were turned off. By placing the tank 2 fans in manual mode, no further overvoltage conditions were observed during the remainder of the mission, and no significant pressure or quantity readout fluctuations were noted with approximately 5-minute motor runs at intervals of 8 to 12 hours.

COMMUNICATIONS

The communications system, which includes voice, telemetry, updata, television, and tracking capability, satisfactorily supported the mission.

The received S-band carrier power levels during the launch phase and the first service propulsion maneuver agree with premission predictions.

The VHF and S-band voice links provided good communications. The onboard television equipment was operated on seven occasions with good picture quality. The playback voice performance varied in quality from noisy to good as received by the network sites during recorder dumps. Some dropouts of both real-time and playback telemetry were noted; however, overall telemetry performance was satisfactory.

Downlink data and voice subcarriers were lost at approximately 65 hours into the mission. Real-time telemetry and television were time-shared on the backup S-band FM mode until full communications capability was restored by switching to the alternate S-band transponder.

The VHF voice duplex-B mode was satisfactory during the countdown and launch phase until about 7 minutes. At that time, voice quality became garbled on downlink receivers and did not completely clear until simplex-A was selected over the Canary Islands tracking station. The operation of the duplex-B mode was successfully reverified at about 7-1/2 hours into the mission. *Review of currently available information indicates that the garbled voice and the failure of the crew to receive attempted transmissions during the launch phase resulted from improper ground operating procedures.*

USS Huntsville lost contact with the spacecraft approximately 2 minutes early during the final revolution. S-band communications blackout at Merritt Island occurred at 259:54:58; the signal was acquired by Bermuda at 259:59:46, the first reported contact after blackout.

The recovery forces reported that the VHF recovery beacon signal was not received during parachute descent. The crew reported that the beacon was turned on at approximately 9000 feet, turned off while the spacecraft was in Stable II after landing, and turned on again when Stable I was achieved. The recovery forces reported reception of the beacon only after the spacecraft returned to stable I position. Postflight testing indicates that the unit is working properly, but the frequency has shifted 1 MHz.

RADAR

A test of the rendezvous radar transponder was successfully completed with the White Sands Missile Range during revolution 48. Approximately 47 seconds of data were obtained. The ground radar acquired and locked-on the spacecraft transponder at a range of 390 n. mi. and tracked to a range of 415 n. mi.

INSTRUMENTATION

The instrumentation performance was satisfactory throughout the mission except for the discrepancies noted. The performance of the data storage equipment was satisfactory throughout the mission.

At 11:09:23, the central timing equipment was reading correctly over *USS Redstone*. At 12:07:26, it was reading 00:42:09, indicating a reset at 11:25:17. The timing equipment was updated at 12:26:20 over Hawaii and continued to read correctly.

The high level commutator failed at 259:43:50. Data from the flight qualification recorder indicate non-synchronous operation. Preliminary postflight tests indicate an abnormally high signal output, but with synchronous operation.

Two discrepancies were encountered with the biomedical instrumentation equipment; these are discussed under Crew Provisions.

DISPLAYS AND CONTROLS

The displays and controls performed satisfactorily throughout the mission.

The crew reported one element out on each of two floodlights, one on the guidance and navigation panel, and the other on the lower equipment bay.

The glass in the mission event timer cracked sometime during the mission.

GUIDANCE AND CONTROL

Guidance and control system performance was satisfactory throughout the mission. *All S-IVB monitoring functions were proper through the ascent phase, and adequate guidance and navigation performance monitoring displays were provided to the crew. Manual attitude control of the S-IVB was successfully demonstrated prior to separation. The inertial measurement unit was optically aligned over thirty times during the mission, including once while still attached to the S-IVB. All alignment options were exercised, all three crew members performed several alignments, and at least one daylight alignment was performed successfully. In all cases, the star angle difference check, made after each alignment, indicated differences of 0.001 degree or less. Backup alignment methods using the crew optical alignment sight (COAS) and the sextant were successfully demonstrated. The inertial measurement unit was brought up from a power-down condition and an inertial orientation successfully established nine times. Daylight star visibility data were obtained for the telescope from star counts made across sunrise and sunset. Some difficulty was experienced in making star sightings following waste dumps or venting when sunlight-illuminated particles entered the optics field of view. Orbital navigation through landmarks tracking was demonstrated using both known and unknown landmark options. Star/earth horizon sightings were attempted but were not successful because the crew was unable to distinguish a useful horizon locator. Star/lunar horizon measurements were made successfully.*

The guidance and navigation system, using optical tracking data, supported the rendezvous with the S-IVB. All significant attitude control modes in both the prime and the backup system were tested and appeared to perform satisfactorily. Thrust vector control of the service propulsion engine was demonstrated using both the guidance and navigation *(five times)* and the stabilization and control system *(twice)*; mid-maneuver manual takeover techniques were also successfully demonstrated *(once)*.

Entry was performed using the automatic mode of the guidance and navigation system. Performance appears proper throughout entry; both rings of the command module reaction control system were used, consuming approximately 50 pounds of propellant. Entry range from 400 000 feet to *landing was approximately 1500 n. mi. The entry monitor system g/velocity trace has been verified correct postflight. Two types of abnormal counter operations occurred at times in flight. Both had been observed before lift-off. Accelerometer bias was within tolerance and the delta velocity counter operated correctly during firings.*

Two hardware problems were encountered. The rotational hand controller minus-pitch breakout switch was reported to have operated inadvertently once early in the mission. The ball on flight director attitude indicator no. 1 indicated an abnormal shift in the pitch axis when being driven by the backup attitude reference system; *postflight tests have failed to duplicate the problem.* No operational capability was lost as a result of either problem.

At 215:59:00, the crew reported that the interior lights had been dimmed to check the visibility of the exterior lights. When the lights were brightened, a computer program alarm existed. The alarm was reset and the problem did not recur.

REACTION CONTROL SYSTEMS

All spacecraft reaction control system parameters were normal throughout the mission, and both systems operated satisfactorily.

The primary service module quad heaters performed normally and maintained all quad package temperatures between 118° and 141° F during the mission. *The maximum quad temperature monitored was 155° F on quad C during rendezvous maneuvers. Quad package temperature limits were 70° F minimum and 210° F maximum. The propellant-tank outlet temperatures, initially at approximately 75° F, gradually decreased, reaching a minimum of 33° F on quad A after 10-1/2 days. The variation in these temperatures followed the individual helium tank temperatures very closely, although the helium tanks remained 5° to 10° F higher at all times.*

The helium regulators for the service module reaction control system maintained the helium and propellant manifold pressures constant *within 4 psi.*

Propellant utilization was near the predicted nominal in most cases. *The isolation of individual quads was necessary to maintain reasonable distribution of usable propellant. The quads were switched from the primary propellant tanks to the secondary tanks based on a 43-percent propellant remaining reading from the ground calculations. The onboard pressure/temperature gage (propellant quantity gaging system) readings at this* *time varied from 46 to 54 percent. These variations probably resulted from temperature calibration effects, because the calibrations at 40° F and 70° F were several percent apart.*

Zero helium leakage was indicated from the command module reaction control system prior to activation just before the deorbit maneuver. The command module engine valve *warm-up procedure* was not required because the engine injector temperatures remained above 46° F prior to system activation. The command module reaction control system performed normally from activation through landing. *Both manual and automatic control were used during entry in combinations of dual- and single-system firings. The total propellant consumed in systems A and B was computed as approximately 29 and 21 pounds, respectively.*

SERVICE PROPULSION SYSTEM

The eight planned firings of the service propulsion engine were performed, and the system operation was satisfactory in all aspects. The actual times, durations, and velocity changes are summarized in table I.

The ignition time for the third maneuver was advanced 16 hours from the original flight plan to improve the margin of deorbit capability with the service module reaction control system. To ensure the verification of the propellant gaging system, the firing time for the fifth maneuver was increased from 61 to 66 seconds so that both point sensors would be uncovered during steady-state engine operation. Propellant quantity data indicate that both sensors were uncovered. After the fifth maneuver, a 3-hour cold-soak test was performed, with no notable decrease in temperatures within the system.

Thermal characteristics of the system appeared to be better than anticipated for random, drifting flight in that the rate of temperature decrease was less than predicted.

ENVIRONMENTAL CONTROL SYSTEM

Performance of the environmental control system was satisfactory. During prelaunch operations, the cabin was purged to an atmosphere of 60-percent oxygen and 40-percent nitrogen. The crew was isolated from the cabin by the suit circuit, which contained 100-percent oxygen. During launch, the cabin sealed off at 5.9 psia. Cabin pressure continued to decrease as a function of the cabin enrichment procedure. This procedure was terminated at about 00:11:00, and the oxygen content was 73 percent of the total cabin pressure. Cabin leakage was estimated to have been 0.1 lb/hr, which agrees with the prelaunch value.

The radiators satisfactorily rejected the spacecraft heat loads to the extent that the evaporators were not required. The primary evaporator is required only when the heat loads exceed the radiator capability; under the low, variable heat loads which existed, the evaporator operated erratically in the automatic mode, causing what appeared to be wick drying and subsequent flash freezing. The automatic control dynamics are such that this condition can be expected. The evaporator was frequently serviced with water in an attempt to keep it working under these conditions but was subsequently turned off.

The secondary coolant loop was tested for 8 hours with the secondary evaporator, which was serviced prior to flight. The test was begun with a heat load of 1400 watts; halfway through the test, the load was increased to 1800 watts. The dynamic response of the secondary evaporator was such that stable operation of the evaporator control system was achieved. Under the automatic demand, the evaporator was required about 50 minutes per revolution during the test. The secondary evaporator operated differently from the primary because the heat load was higher as a result of the lower capacity of the secondary radiators.

Moisture condensed on cold, uninsulated coolant lines, as anticipated, and was dumped overboard by the crew utilizing the urine transfer hose and cabin enrichment purge assembly. Some condensation was also noted in the suit umbilical hoses.

A water leak was observed at the B-nut connection to the waste water quick disconnect during the overboard dumps.

The urine dump system operated normally and no indication of freezing was observed.

Postflight testing has revealed that the two check valves which induce mixing of the injected chlorine solution into the potable water supply have high internal leakage. This condition would cause some fraction of the injected chlorine fluid (5000 ppm) to bypass the tank and flow directly to the crew withdrawal points.

Both cabin fans were operating at lift-off; however, one was turned off after orbital insertion to reduce the high noise level. The second cabin fan was subsequently turned off. The measured cabin temperature was between 65° and 75° F and was not significantly affected by fan operation.

CREW PROVISIONS

The crew equipment operated satisfactorily during the mission with the exception of the biomedical instrumentation equipment and the water metering dispenser.

Two discrepancies were encountered with the biomedical instrumentation equipment. First, a wire was broken at the connector to the EKG signal conditioner on each of two harnesses. In addition, the pin connectors to the sensors periodically became disconnected. Second, the dc-dc converter on the command module pilot was reported to have become *hot to the touch (approximately 120° F).* As a precautionary measure, the harnesses were disconnected from all three crewmen. *Postflight testing of the dc-dc converter has indicated that the unit operates nominally relative to all specified values. The spacecraft circuits were satisfactory during postflight testing; however, a blue-green foreign substance was found in the electrical connections on each end of the control head of the biomedical/communications cabling. This substance is being analyzed.*

The manual triggering device for the water metering dispenser became increasingly difficult to operate as the mission progressed. *Postflight testing has shown that the metering O-ring increased in outside diameter. A new O-ring was installed in the flight article, and the trigger actuator forces returned to specified limits. The Neoprene O-ring is not compatible with chlorine and therefore tends to swell.*

A functional deficiency was encountered with the sleeping bags in that the lower end of the bag allowed lower leg motion. A change is being implemented to add restraint straps to both corners of the foot end of the bag.

FLIGHT CREW ACTIVITIES

Crew performance was satisfactory throughout the mission, even though all three crewmen had head colds and congestion.

The mission was conducted essentially in accordance with the nominal flight plan. The only significant alteration to the flight plan was the rescheduling of the third service propulsion maneuver from the 58th to the 48th revolution. Additional photography was accommodated during the latter portion of the mission.

The crew station was adequately configured for this mission, and only minor changes, such as the sleep restraint and shielding of some main display instruments from sun glare, are required for subsequent missions.

The crew quickly became adapted to moving about the cabin under zero-g conditions; therefore, no special restraints are required for intravehicular activity.

The crew reported that the hand controllers were somewhat susceptible to inadvertent activation during intravehicular motion.

The deorbit, entry, and landing sequences were accomplished normally. The spacecraft assumed the stable II (apex-down) attitude after landing and was uprighted to the stable I (apex-up) position by inflation of the uprighting bags. The crew elected a helicopter pickup for the approximately 3-mile trip to the recovery carrier.

Entry accelerations were reported to be low and landing was soft, presenting no discomfort to the crew.

MISSION SUPPORT PERFORMANCE

FLIGHT CONTROL

Flight control performance was satisfactory for the entire mission.

NETWORK

Network performance was satisfactory during the mission. Several minor problems were encountered, but none affected the mission operations.

RECOVERY

Recovery operations were successfully effected in the West Atlantic by the prime recovery ship, *USS Essex*, on October 22, 1968. The following table lists the major recovery events on October 22, 1968:

Greenwich mean time, hr:min	Event
11:05	S-band contact by recovery aircraft
11:07	VHF voice reception by *USS Essex*
11:08	Landing
11:24	VHF recovery beacon contact by recovery helicopters
11:32	Visual sighting by recovery helicopter
11:34	Swimmers and flotation collar deployed
11:43	Flotation collar installed
11:47	Command module hatch open
12:00	Flight crew aboard helicopter
12:08	Flight crew aboard recovery ship
13:03	Command module aboard recovery ship

The weather conditions reported by the recovery ship at the time of command module retrieval were as follows:

Wind direction, deg true	260
Wind speed, knots	16
Sea state	3-foot waves at 3-second intervals from 260 deg and 3-foot swells at 3-second intervals from 110 deg
Air temperature, °F	74
Cloud cover	600-foot overcast
Water temperature, °F	81
Visibility, n. mi.	2

The spacecraft condition at retrieval, according to the initial report, was as follows:

Heating effects - Aft heat shield was normal but the crew compartment heat shield was charred less than expected.

Windows - All windows fogged between panes, clearing within approximately 4 hours. Right and left rendezvous windows had very thin rainbow residue which did not clear.

Apex cover - Not sighted; however, a piece of insulation material believed to be off the apex cover was recovered.

Main parachutes - Not sighted after normal separation. The flight crew reported seeing them sink shortly after separation.

Interior - About 2 gallons of water were found, and a sample was taken.

EXPERIMENTS

Two experiments, Synoptic Terrain Photography and Synoptic Weather Photography, were included on this mission. Preliminary information indicates that most of the terrain photography was performed, *and 203 useful color photographs were obtained.*

For meteorological photography, 27 phenomena were of interest; at least 7 were apparently photographed and 8 others may have been. The most successful was photography of tropical storms. Three storms were in view of the spacecraft, two of which reached hurricane intensity. *Excellent photographs were obtained of Hurricane Gladys and the eye of Typhoon Gloria, in addition to cumulus cloud streets in many areas and under a variety of wind conditions, eddies in the lea of islands, mountainous area showing the detailed distribution of snow, cirrus clouds in many configurations, and smoke plumes. Of particular interest to oceanography are views of underwater bottom configurations, the distribution of turbid river effluents, and sea swells.*

AEROMEDICAL

No abnormal physical findings were found on preflight examinations. Postflight, the only physical findings of note were minor residual signs of a cold and a minor serous otitus media in the right ear of one crew member.

During the flight, physiological data about the electrical activity of the heart and respiration were telemetered for the first 8 days of the flight. The 1-sigma distribution of sampled flight data indicate that the Commander's heart rate ranged between 53 and 91 beats/min, the Command Module Pilot (CMP) between 61 and 99 beats/min, and the Lunar Module Pilot (LMP) between 50 and 90 beats/min. While the CMP exhibited a significantly higher mean heart rate than the other crewmen. All observed heart and respiration rates were normal.

A variety of biochemical and microbiological tests were conducted on each crewmember before and after flight. A preliminary analysis of laboratory results shows no alteration in any vital parameters.

Preliminary results of bone densitometric tests performed on the crewmembers indicate that the losses in bone density during the flight were the lowest recorded on any mission to date. It is speculated that the intravehicular activities undertaken by the crew were partially responsible for these results.

Four of the 294 rehydratable food bags failed. All failures were associated with the installation of the mouth piece and represent an inspection problem, not design or material failures. Beef stew bites were the main item which caused crumbs, and this item shall be removed from future menus. An analysis of the potable water conducted 28 hours after the final inflight chlorination indicates an above normal content o bacteria.

TABLE I.- MANEUVER SUMMARY

Maneuver	Time, hr:min:sec	Duration, sec	Velocity change, ft/sec	Apogee/perigee, n. mi.
Phasing (reaction control system)	03:20:21	16.3	5.7	124/165
Phasing (reaction control system)	15:52:00	18.5	6.5	120/164
First service propulsion	26:24:55	10.0	206	125/196
Second service propulsion	28:00:56	7.8	175	114/153
Terminal phase initiate (reaction control system)	29:17:55		16.7	122/153
Terminal phase finalize (reaction control system)	29:54:33		17	122/161
Separation (reaction control system)	30:20:00	5.4	2	122/161
Third service propulsion	75:47:59	9.3	215	90/160
Fourth service propulsion	120:43:00	0.5	15.3	90/158
Fifth service propulsion	165:00:00	67.6	1692.0	90/245
Sixth service propulsion	210:08:00	0.5	18.6	90/236
Seventh service propulsion	239:06:11	7.9	227	90/231
Eighth service propulsion	259:39:16	11.8	350	

TABLE II.- ORBITAL ELEMENTS

Event	Condition	Before	After
Insertion	Apogee, n. mi. . . .		153.5
	Perigee, n. mi. . . .		122.6
	Period, min		89.70
	Inclination, deg . .		31.64
S-IVB safing	Apogee, n. mi. . . .	153.5	167.0
	Perigee, n. mi. . . .	122.6	122.8
	Period, min	89.70	89.86
	Inclination, deg . .	31.64	31.61
Reaction control system phasing maneuver	Apogee, n. mi. . . .	167.0	165.1
	Perigee, n. mi. . . .	122.8	124.1
	Period, min	89.86	89.88
	Inclination, deg . .	31.61	31.62
Reaction control system phasing maneuver	Apogee, n. mi. . . .	164.8	164.4
	Perigee, n. mi. . . .	123.9	119.8
	Period, min	89.87	89.75
	Inclination, deg . .	31.62	31.61
First service propulsion system maneuver	Apogee, n. mi. . . .	164.0	196.1
	Perigee, n. mi. . . .	119.9	125.1
	Period, min	89.75	90.43
	Inclination, deg . .	31.62	31.62
Second service propulsion system maneuver	Apogee, n. mi. . . .	196.1	153.1
	Perigee, n. mi. . . .	125.1	113.6
	Period, min	90.43	89.43
	Inclination, deg . .	31.61	31.62
Terminal phase initiation	Apogee, n. mi. . . .	153.1	153.9
	Perigee, n. mi. . . .	113.6	121.7
	Period, min	89.43	89.65
	Inclination, deg . .	31.62	31.62

TABLE II.- ORBITAL ELEMENTS - Concluded

Event	Condition	Before	After
Terminal phase finalize	Apogee, n. mi. . . . Perigee, n. mi. . . . Period, min . . . . . Inclination, deg . .	153.9 121.7 89.65 31.62	161.4 121.6 89.76 31.62
Separation after rendezvous	Apogee, n. mi. . . . Perigee, n. mi. . . . Period, min . . . . . Inclination, deg . .	161.4 121.6 89.76 31.62	161.5 122.0 89.83 31.64
Third service propulsion system maneuver	Apogee, n. mi. . . . Perigee, n. mi. . . . Period, min . . . . . Inclination, deg . .	159.3 121.5 89.68 31.61	160.0 90.3 89.13 31.23
Fourth service propulsion system maneuver	Apogee, n. mi. . . . Perigee, n. mi. . . . Period, min . . . . . Inclination, deg . .	150.7 88.9 88.99 31.23	157.5 90.3 89.15 31.25
Fifth service propulsion system maneuver	Apogee, n. mi. . . . Perigee, n. mi. . . . Period, min . . . . . Inclination, deg . .	148.6 89.4 88.87 31.22	244.7 89.8 90.72 31.07
Sixth service propulsion system maneuver	Apogee, n. mi. . . . Perigee, n. mi. . . . Period, min . . . . . Inclination, deg . .	236.3 90.1 90.61 30.10	236.2 90.2 90.61 30.06
Seventh service propulsion system maneuver	Apogee, n. mi. . . . Perigee, n. mi. . . . Period, min . . . . . Inclination, deg . .	230.8 90.2 90.51 30.07	231.3 90.0 90.51 29.86
Eighth service propulsion system maneuver (deorbit)	Apogee, n. mi. . . . Perigee, n. mi. . . . Period, min . . . . . Inclination, deg . .	227.0 90.0 90.45 29.89	

TABLE III.- SEQUENCE OF EVENTS

Event	Time, hr:min:sec	
	Planned	Actual
Launch Phase		
Range zero (15:02:45 G.m.t.)		
Lift-off (15:02:45.36 G.m.t.)	00:00:00.2	00:00:00.36
Maximum dynamic pressure	00:01:15.6	00:01:15.5
S-IB inboard engine cutoff	00:02:20.28	00:02:20.65
S-IB outboard engine cutoff	00:02:23.28	00:02:24.32
S-IB/S-IVB separation	00:02:24.58	00:02:25.59
S-IVB engine ignition	00:02:25.98	00:02:27.06
Escape tower jettison	00:02:43.28	00:02:46.54
S-IVB engine cutoff	00:10:14.80	00:10:16.76
Orbital Phase		
Orbital insertion	00:10:14.8	00:10:26.76
S-IVB safing start	01:34:27.0	01:34:28.96
S-IVB safing terminate	01:46:28.0	01:46:29.96
S-IVB takeover	02:29:55	02:31:21
CSM/S-IVB separation	02:54:55.17	02:55:02
First phasing maneuver (RCS) start	03:20:00	03:20:09.87
First phasing maneuver (RCS) cutoff	03:20:16.3	03:20:37.3
Second phasing maneuver (RCS) start	15:52:00	15:52:00
Second phasing maneuver (RCS) cutoff	15:52:18.5	Not avail.
First service propulsion ignition	26:24:55.2	26:24:55.68
First service propulsion cutoff	26:25:04.7	26:25:05.09
Second service propulsion ignition	28:00:56.0	28:00:56.46
Second service propulsion cutoff	28:01:03.8	28:01:04.29
Terminal phase initiate (RCS) start	29:18:34.0	29:17:55
Terminal phase finalize (RCS) on	29:53:34	29:54:33

TABLE III.- SEQUENCE OF EVENTS - Concluded

Event	Time, hr:min:sec	
	Planned	Actual
Orbital Phase - Concluded		
Separation maneuver (RCS) start	30:20:00	30:20:00
Separation maneuver (RCS) cutoff	30:20:05.4	30:20:05.4
Third service propulsion ignition	75:47:58.6	75:48:00:29
Third service propulsion cutoff	75:48:07.8	75:48:09.34
Fourth service propulsion ignition	120:43:00	120:43:00
Fourth service propulsion cutoff	120:43:00.4	120:43:00.5
Fifth service propulsion ignition	165:00:00	165:00:00
Fifth service propulsion cutoff	165:01:05.9	165:01:07.6
Sixth service propulsion ignition	210:08:00	210:08:00.47
Sixth service propulsion cutoff	210:08:00.4	210:08:00.98
Seventh service propulsion ignition	239:06:11	239:06:11
Seventh service propulsion cutoff	239:06:18.8	239:06:18.9
Eighth service propulsion ignition	259:39:15.9	259:39:15.9
Eighth service propulsion cutoff	259:39:27.9	259:39:27.7
Entry Phase		
Command module/service module separation	259:43:33.2	259:43:33.2
Entry interface (400 000 feet)	259:53:26	259:53:25.29
Enter blackout	259:56:17	259:54:58
Leave blackout	259:59:14	259:59:46
Drogue deployment	260:03:28	260:03:22
Main parachute deployment	260:04:14	260:04:13
Landing	260:08:58	260:09:08